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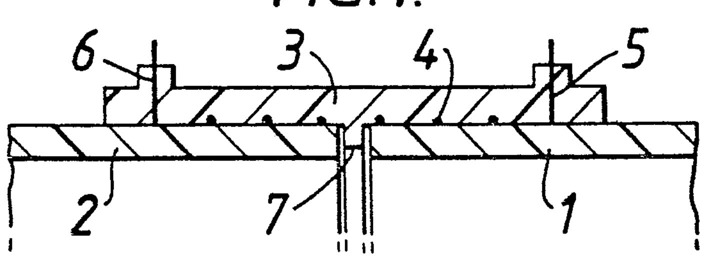
(54) Process for the jointing of polyolefin bodies.

(57) The invention provides a method of joining a body of crosslinked polyolefin to a body of non-crosslinked polyolefin comprising the steps of melting the surface of the non-crosslinked polyolefin body to be joined and heating the surface of the crosslinked polyolefin body to be joined and bringing together said melted and heated surfaces of the body under pressure and allowing the surfaces to cool and harden.

FIG. 1.



EP 0 333 379 A2

Process for the Jointing of Polyolefin Bodies

This invention relates to a process for jointing polyolefin bodies, and more particularly such bodies formed of one or more polyolefins capable of forming molecular crosslinking bonds, such as polyethylene and its co-polymers.

It is, of course, known to join polyolefin bodies or articles, such as pipes, where the polyolefin is not crosslinked, by a fusion welding technique of one form or another in which surfaces of the polyolefin articles are caused to become molten, and the surfaces then press together whilst still molten and then allowed to cool and harden so that the two surfaces are "fused" or "fusion-welded" together.

The use of the crosslinking technique to articles of such polyolefin materials can be extremely beneficial in giving greater permanence of structure, rigidity and resistance to heat to the article which effectively ceases to be of a thermoplastic nature. Following from this, however, a most significant disadvantage is that it has not hitherto been found possible to join by a melting or fusion welding technique crosslinked polyolefin articles, or articles having a crosslinked body portion at the area to be connected, to either polyolefin products be they crosslinked or not crosslinked.

It is an object of the present invention to overcome the above mentioned problem and to enable the fusion jointing of a body of crosslinked polyolefin with an article of non-crosslinked polyolefin.

In accordance with one aspect of the present invention there is provided a method of joining a body of crosslinked polyolefin to a body of non-crosslinked polyolefin comprising the steps of melting the surface of the non-crosslinked polyolefin body to be joined and heating the surface of the crosslinked polyolefin body to be joined, and bringing together said melted and heated surfaces of the bodies under pressure, and allowing the surfaces to cool and harden.

In accordance with another aspect of the present invention there is provided a method of joining a body of crosslinked polyolefin material to a body of non- crosslinked polyolefin material comprising the steps of heating the surfaces of both bodies at which they are to be joined to one another, to a temperature at which the surface of the non-crosslinked body is melted; subjecting the two contacting surfaces to pressure whilst so heated, and ensuring containment or confinement of the melted surface of the non-crosslinked polyolefin body generally to its area of melting; and subsequently allowing the two surfaces to cool and harden.

It has been found that by applying a pressure, such as that provided if the two surfaces are pressed together with confinement or containment of the melt to the area of the surface melted, jointing by fusion of the two surfaces of the bodies can surprisingly be achieved.

It is believed that the surprising process of fusion jointing crosslinked polyolefin to non-crosslinked polyolefin is brought about by the combination of heat and pressure (caused for example by containment of the melt under applied pressure) allowing polymer long chain molecures from the non-crosslinked polyolefin to enter the molecular interstices of the heated crosslinked polyolefin molecular network and to intermingle with it, providing a strong fusion jointing of the two materials.

The bodies or articles concerned may be any of the many practical embodiments and usages of crosslinkable polyolefin bodies, and in particular may comprise polyolefin pipes and pipe fittings, or cable sheathings, for example.

With some techniques of fusion welding, which may be used with the present invention, in some instances the application of the necessary pressure can be provided by expansion of the polyolefin materials during heating, provided melt containment or confinement is practised.

The invention is particularly, but not exclusively, applicable when electrofusion techniques are used, in which a portion of the area of the relevant surface of the non-crosslinked polyolefin article has embedded therein a heating wire adapted, on the passage of an electric current therethrough, to heat and melt the adjacent surface portion. When this is done with the relevant surface contacting a surface of a crosslinked polyolefin body or article, it is possible to ensure that the surfaces are held together in such a manner as to provide confinement or containment of the molten surface of the non-crosslinked polyolefin, whilst the expansion of the materials as they heat and melt provides the excess pressure required.

It is to be stressed that the Applicants have found that in practical terms the required pressure is that which is required to ensure intimate contact at the melt interface between the two materials to be joined. In the case of two uncrosslinked materials being welded together, both materials would easily soften and flow at elevated temperature rapidly giving the required melt interface, but when one of the materials is crosslinked it will remain intractable at elevated temperature thus often requiring more care in ensuring that there is intimate contact at the melt interface.

In practice in carrying out the invention, the surfaces must be held together in a pressurised melt contained condition for adequate time to enable migration of molecular chains from the molten non-crosslinked polyolefin into the surface of the crosslinked polyolefin and ensure adequate and satisfactory fusion or welding.

It is to be understood that, although the invention is particularly applicable with electrofusion techniques, it can be carried out in any other circumstance where an appropriate pressure and melt containment or confinement can be applied. Thus, and purely by way of example, electrofusion techniques using a conductive polymer instead of wire can be employed; inductive heating of an embedded wire, metal loop, metal sheet, grid or other form within an enclosed system similar to conventional electrofusion welding techniques; other radiative heating methods using electromagnetic radiation, e.g. microwave energy, to heat either modified polymers or inserted receptive components and transfer heat; and butt (or socket) welding or joining of articles within a confined space where weld movement is restricted from flowing freely away from the weld zone, whereby there is an increase in melt pressure significantly over and above that normally encountered in butt (or socket) welding of this kind; and other methods using heating by friction or ultrasonic means but employing similar restrictions on melt movement and application of pressure may also be employed.

Pipes or sheathings to which the invention may be applied would include, but not be restricted to, under floor heating and hot/cold water pipes; electrical cable sheathing; steel cable sheathing; district heating pipes and sheathing; flue pipes; industrial pipes; chemical plant pipes.

The invention includes within its scope a joint between a crosslinked polyolefin body and a non-crosslinked polyolefin body formed by a method as herein defined.

In order that the invention may be more readily understood, a number of embodiments of the use of the method of the present invention will now be illustrated with reference to the accompanying drawings in which:

Figure 1 is a schematic sectional elevation through one half of a first embodiment of a pipe joint in accordance with the invention;

Figure 2 is a similar sectional elevation of a second embodiment of a pipe joint in accordance with the invention;

Figure 3 is a similar sectional elevation of a third embodiment of a pipe joint in accordance with the invention;

Figure 4 is a similar sectional elevation of a fourth embodiment of a pipe joint in accordance with the invention;

Figure 5 is a similar sectional elevation of a fifth embodiment of a pipe joint in accordance with the invention;

Figure 6 is a similar sectional elevation of a sixth embodiment of a pipe joint in accordance with the invention;

Figure 7 shows a joint for connecting cable sheathing;

Figure 8 shows a technique for mending or repairing damaged cable sheathing; and

Referring now to the drawings, it will be seen that in Figure 1 there is illustrated a technique for coupling two crosslinked polyethylene pipes 1, 2 by means of a non-crosslinked polyethylene annular coupling sleeve 3. The non-crosslinked polyethylene sleeve is provided with an electrical wire heating element wound helically within it connecting between electrical terminal wires 5, 6. A removable central annular internally protruding register 7 is provided to locate against the ends of the two crosslinked polyethylene pipes. In operation, after assembling the two pipes 1, 2 within the sleeve so as to engage the centre register, electrical current is passed through the wire 4 embedded in the non-crosslinked polyethylene sleeve, so that the non-crosslinked polyethylene melts at its inner surface, whilst the polyethylene pipes are heated on their external radial surfaces.

The heating of the component materials of the inner surface of the non-crosslinked polyethylene layer of the sleeve, and the radially outer surfaces of the juxtaposed pipes, causes a tendency to expand so that their mating surfaces are pressed together under considerable pressure from such expansive force.

Upon disconnecting the electrical terminal wires 5, 6, the sleeve 3 and the pipes 1 and 2 cool and harden and it is found that a most satisfactory joint between the pipes through the use of the sleeve is achieved. The joints are not only firm but are also fluid-tight, and can satisfactorily be subjected to pressure testing at elevated temperature.

In an alternative arrangement a coupling, particularly using a large fitting or sleeve, may incorporate a crosslinked polyolefin formed for example by irradiation or by chemical means, and carrying an embedded heating coil. In this case the sleeve is juxtaposed with and then fused to inserted non-crosslinked polyolefin pipes.

It is, of course, possible to subject the finished connection, including the coupling, to irradiation treatment to provide crosslinking of the non-crosslinked polyethylene sleeve. Alternatively, the sleeve body may be a modified polyethylene containing a crosslinking initiator such as a peroxide initiator, so that during the heating, melting and jointing cycle, the initiator, due to the action of the heat, will ensure crosslinking of the polyethylene sleeve body.

A specific test example of the arrangement of Figure 1 is as follows:

Two one metre sample lengths of 125mm SDR11 quality polyethylene pipe were irradiated with a Cobalt 60 source to bring about crosslinking of the polyethylene such that when the gel content was measured using a Soxhlet extraction technique, 5 hours with xylene as a solvent, the gel content was found to be 70%. The two crosslinked pipes were inserted into a conventional 125mm electrofusion coupler gas fitting and current passed giving a fusion time of 220 seconds. After allowing cooling the fusion welded assembly was subjected to hydrostatic testing at 80°C and a test pressure of 8bar. Failure of the assembly did not occur for more than 3000 hours.

A modification of the arrangement of Figure 1 is shown in Figure 2. In this case, a rigid sleeve coupling is ensured by means of an outer annular crosslinked polyethylene casing 8 within which is located a non-crosslinked polyethylene liner sleeve 9 with an embedded wire heating element 4. Operation of the jointing method is as with the embodiment of Figure 1.

Figure 3 is similar except that, in this case, rigidity is provided by an annular metal case 10.

The arrangement of Figure 4 is similar to that of Figure 2, except that in this case a unitary sleeve 11 is provided, the sleeve having been previously irradiated by gamma ray or electron beam in such a manner that a radially outer layer 12 is crosslinked, whilst the radially inner layer 13 and inner surface remain non-crosslinked. The usual embedded wire elements enable the heating and weld jointing to take place. Such an arrangement may be subsequently irradiated again to complete the crosslinking of the whole jointing sleeve 11.

The arrangements of Figures 1 to 4 can be modified by using internal jointing sleeves for the pipes.

Figure 5 illustrates an arrangement in which a crosslinked polyethylene fitting 14 or pipe is provided with a thickened annular end portion 15, (the fitting and the end portion being of crosslinked polyethylene) with an annular axially extending insert or body 16 in the end of the fitting formed of non-crosslinked polyethylene. This can be joined to a second crosslinked polyethylene pipe 1 by heating both ends on a hotplate and then pushing them together in a similar manner to normal butt fusion welding. In this particular instance, the melting portion of the uncrosslinked polyethylene annular insert surface is confined or contained by the surrounding crosslinked polyethylene portion, hence enabling the success of the weld joining of the present invention.

Figure 6 shows another form of jointing a pipe 1 to a fitting 17 or pipe. In this arrangement, the fitting has a body or ring 18 of non-crosslinked polyethylene provided at its end, the ring 18 having the same annular dimensions as the end of the fitting 17 from which it extends is connected in accordance with the invention to a crosslinked polyethylene pipe 1. The abutting ends of the pipe 1 and the ring 18 of non-crosslinked polyethylene are pressed together within collapsible inner and outer formers 19 and 20 respectively on either side. The formers have axially outer support portions 21, 22, 23, 24 which act to constrain the flow of melt from the ring of non-crosslinked polyethylene (enabling the functioning of the process of the present invention) and central heating portions 25, 26. After cooling, the formers can be removed and to assist this may be provided with anti-stick coatings.

Figure 7 illustrates a connection between crosslinked polyethylene cable sheathing 27, 28, in which the connection is by means of an electrofusion technique. A sleeve 29, tapering from its central portion, of non-crosslinked polyethylene and having embedded an electrical heating wire 30 is fitted about the proposed connection between the sheathing 27, 28. The sleeve 29 may be modified and contain a peroxide initiator. Upon heat application, the usual process of heating the crosslinked sheathing outer surface and melting the sleeve inner surface adjacent to the electrical heating wire, leads to expansion pressure, and containment of the melt from the non-crosslinked sleeve which enables an adequate fusion joint to take place. At the same time, the peroxide initiator within the modified polyethylene sleeve bring about its crosslinking. Electrical terminal wires 31, 32 are conveniently removed after use.

Finally, Figure 8 illustrates a variation of the arrangement shown in Figure 7. In this case, a crosslinked polyethylene heat-shrink tube 33 is used for the repair and insulation of a damaged cable sheathing 34. As usual, the cable sheathing is of crosslinked polyethylene. At each end of the heat-shrink tube an appropriately shaped fillet sleeve 35 tapering to the outer diameter of the cable is inserted under the heat-shrink tubing. Electrofusion heating elements 36, 37 are embedded within the fillet sleeves 35 but separated from both ends of each. Upon passing current through the electrofusion heating elements, a fusion seal between the cable sheathing 27, 28, the fillet sleeves 35 and the heat-shrink tube 33 is obtained. The heat-shrink tube may be shrunk upon the cable sheathing and fillet sleeves either before or during the fusion jointing process. Electrical terminal wires 38, 39 may again be removed after use.

By means of the invention, a surprisingly successful method of jointing non-crosslinked polyolefin bodies with crosslinked bodies and, indeed, (through the intermediary of the body portions of non-crosslinked polyolefin) of jointing crosslinked polyolefin bodies.

Claims

1. A method of joining a body of crosslinked polyolefin to a body of non-crosslinked polyolefin comprising the steps of melting the surface of the non-crosslinked polyolefin body to be joined and heating the surface of the crosslinked polyolefin body to be joined, and bringing together said melted and heated surface of the bodies under pressure, and allowing the surfaces to cool and harden.

2. A method of joining a body of crosslinked polyolefin material to a body of non-crosslinked polyolefin material comprising the steps of heating the surfaces of both bodies at which they are to be joined to one another to a temperature at which the surface of the non-crosslinked body is melted, subjecting the two contacting surfaces to pressure while so heated and ensuring containment or confinement of the melted surface of the non-crosslinked polyolefin body generally to its area of melting; subsequently allowing the two surfaces to cool and harden.

3. A method as claimed in Claim 1 or 2 wherein the bodies comprise polyolefin pipes, pipe fittings and/or cable sheathings.

4. A method as claimed in any one of the preceding claims in which the application of pressure is provided by expansion of the polyolefin materials during heating and in the presence of melt containment or confinement.

5. A method as claimed in any one of the preceding claims wherein heating and melting of the relevant surfaces is provided by means of an electrofusion technique in which a heating wire embedded in one body adjacent the relevant surface thereof is heated by the passage of electric current thereof to heat and melt the adjacent surface portion of the non cross-linked polyolefin body whilst the surfaces are held together with confinement or containment of the molten surface of the non-crosslinked polyolefin body, the expansion of the materials as they heat and melt providing pressure at the melted surfaces.

6. A method as claimed in any one of Claims 1 to 4 in which an electrically conducted polymer is included within one or more of the articles, heating being provided by passing electric current therethrough.

7. A method as claimed in any one of Claims 1 to 4 wherein heating of the relevant surfaces of the articles is by means of radiative or inductive heating.

8. A joint between a crosslinked polyolefin body and a non-crosslinked polyolefin body formed by a method as claimed in any one of the preceding claims.

FIG.1.

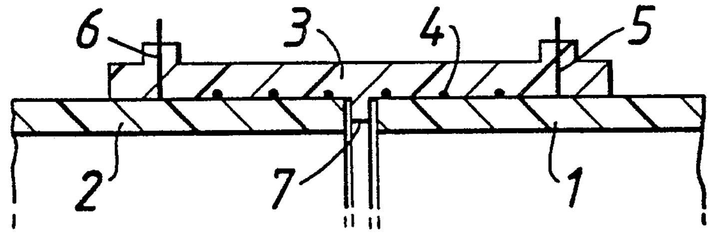


FIG.2.

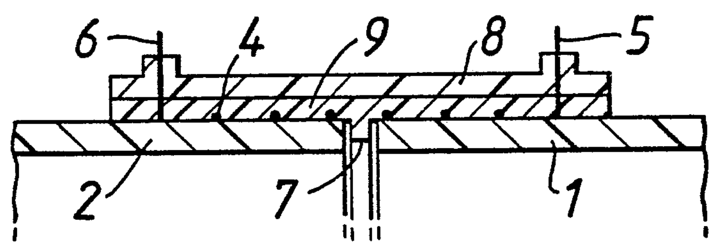


FIG.3.

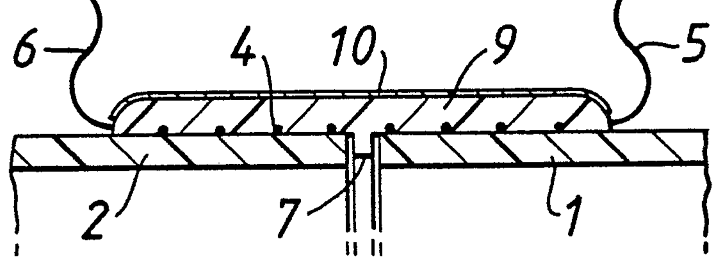


FIG.4.

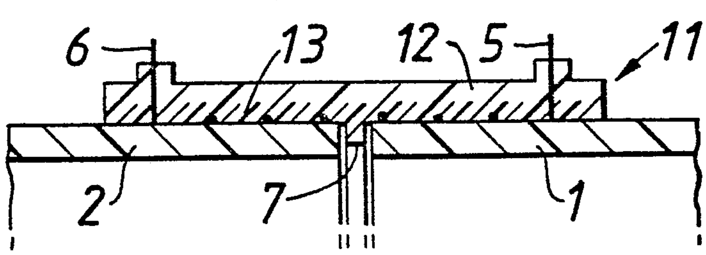


FIG. 5.

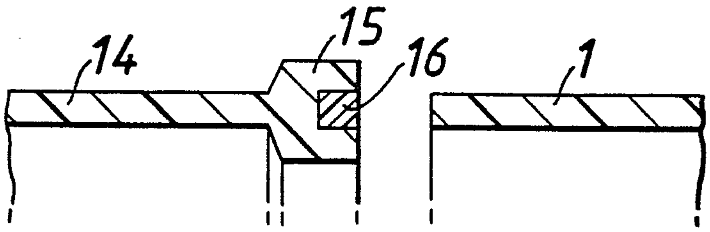


FIG. 6.

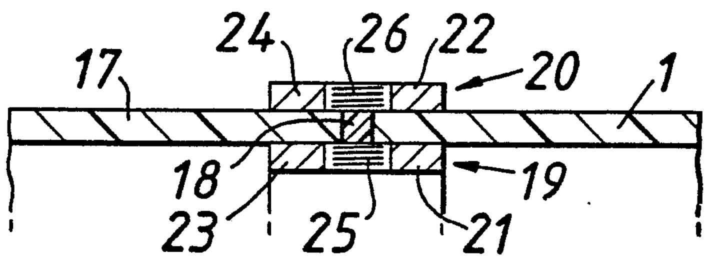


FIG. 7.

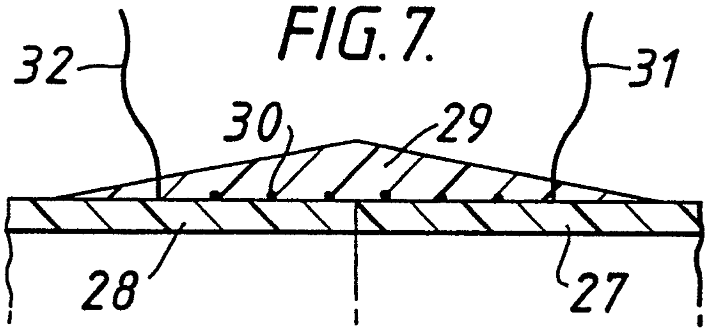


FIG. 8.